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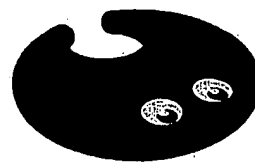
Mobile Agents:

Going beyond the Web

TRYLLIAN BV

VERSION 1.0

MAY 2000



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INTRODUCTION

Imagine a world where your customers are serviced wherever they are in the world by their own personal digital assistants. A world in which autonomous computer programs authorized to act as your virtual representatives provide sales information and content to your customers whether they are at home or moving about their everyday lives. These programs, called *mobile agents*, can work 24 hours a day, seven days a week: they can look up information in databases, bundle your services and products for each individual customer, create networks for information exchange and retrieval, and perform remote management for diagnosis and repair.

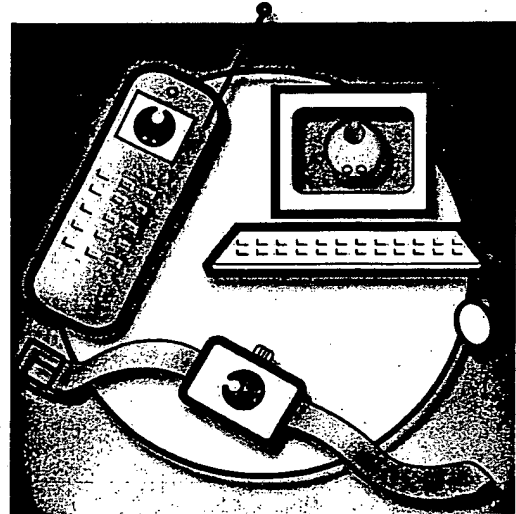
Mobile agents give you the power to increase your customer network exponentially, staying in contact with your customers while moving from one device to another. They behave like autonomous characters running on computers, mobile phones, personal assistant devices, or any device your customer may be using at the time. If the user is connected to a network, the mobile agent can decide on its own, or be instructed by its user, to meet up with him or her at another location and continue working there.

Tryllian mobile agents use sophisticated user profiling technology to know what their users expect from them, and act independently and pro-actively on their user's behalf. Moreover, the agents have a degree of intelligence that allows them to learn from their own experience, from their experiences with other agents and from user feedback. In other words, the more customers use them, the smarter they get.

The potential of mobile agent technology is enormous, both from a business and from a user perspective. For not only can they serve as e-commerce tools, community builders, and online shop assistants; mobile agents are also ideally suited for carrying out on-site repairs and diagnostics, both within internal networks and at remote locations

Tryllian technology brings the power of mobile agents to your business today. Devices running our mobile agent software act as part of the mobile agent infrastructure or AgentWorld on which your agents can exist, communicate and travel. Whether your business is an Internet or Application Service Provider, Web Portal, or any other industry, our mobile agent technology will have instant impact on your customers.

Tryllian has developed a distributed mobile agent system that will make mobile agents the ubiquitous Internet computing assistant they were always promised to be. Using a combination of sophisticated state-of-the-art technologies and cutting-edge system architecture, Tryllian's mobile agent system is the only one to include advanced security features. Being based on Java, it will run on any computer system, is adaptable to other devices (like hand-held computing devices, mobile phones, PDA's, etc.), and is customizable and extensible, both from the user's and developer's perspective.



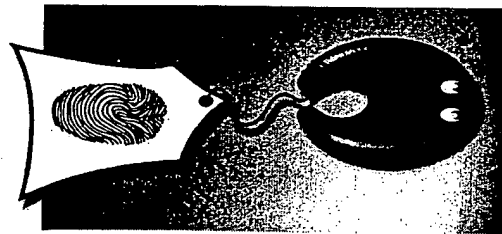
1 TRYLLIAN'S MOBILE AGENT INNOVATIONS

Mobile agent systems have been a popular item in academic circles for years. Although smaller-scale projects have proved that mobile agent technology can be incredibly effective, no viable commercial enterprise level application has been presented to date. Tryllian is the first to offer a full-scale commercial mobile agent application, featuring KnowYou® user profiling, AgentFace® customizable user interfaces, DataGuard® security and a full AgentWorld® environment.

1.1 KNOWYOU® PROFILES

*Your agent
knows what
you want*

One of the most important aspects of our mobile agents is their ability to understand their user's preferences when collecting information. Tryllian agents succeed where others fail because the customer profile is the foundation for their behavior. They use it to predict what content and products are of interest to their user. This profile is based on user interaction, agent-to-agent communication, and advanced trend analysis.



Mobile agents look for other agents with similar user profiles in order to share their data and collaborate to enhance both agents' profiles. The user profile is what enables agents to be truly proactive. For example, a user can send out a buyer agent with a specific query like "Find me a DVD-player for less than \$ 300", in which case the agent would only be able to report back on the success or failure of its mission. By contrast, a Tryllian mobile agent armed with KnowYou profiling technology can do much more.

In its search for the DVD-player, it might come across other mobile agents with similar user profiles and find that they bought certain types of DVD movies or surround-sound speaker sets in addition to the DVD player within the \$300 price range. The agent could return with the announcement:

'Not only did I find the most popular DVD-player at the price you indicated, I also found these additional items, which I thought might be of interest to you.' The user can indicate whether or not he found the secondary search results useful, and this feedback goes straight into the user profile.

In this fashion, the agent will continue to sharpen its skills, getting to know its user's preferences better and better. Constant user interaction ensures that the resulting profile reflects true user preferences at all times. The user profile is further developed through a sophisticated system that combines direct feedback from the agent with statistical data from the server. This model not only gives businesses the best possible information about their customers, it also gives customers the best results specifically tailored to their wishes and demands.

1.2 AGENTFACE® INTERFACE

*Choose a look
for your agent*

A user-based mobile agent environment must be equipped with an interface so customers can communicate with and receive feedback from their agent. This interface can be graphical, as in current versions, but can in future also be driven by voice-recognition technology, so you can literally tell your agent what to do.

Tryllian mobile agents come with a customizable graphical user interface that clearly and intuitively visualizes the mobile agent technology. This means that business developers have a choice as to how they represent their content and business to the user. Developers can select from a number of different standard interfaces with AgentFace when designing a mobile agent application with Tryllian's Agent Development Kit. The developer can also decide to offer users a variety of different looks or 'skins' for the application, so the user can customize the mobile agent application according to his own preferences.

1.3 DATAGUARD® SECURITY

*Tryllian
mobile agents
cannot be
mugged or
kidnapped*

Tryllian is strongly committed to the security of its mobile agent environment. Tryllian's mobile agent software is constructed with state-of-the-art security to ensure a safe computing environment. As a business or a

customer, you don't want your mobile agents to be accessed or opened by others. Also, you want to be sure that your agents can't be modified while outside your direct control.

DataGuard protects agents from other agents who try to interfere with operations or forge identities. All Tryllian agents execute only secure and trusted operations. No agent is able to obtain private information from another agent without the owner's certification and consent.

Tryllian's threefold protection of mobile agents and user data:

- **Secure lines.**

Tryllian Mobile Agents use encrypted Secure Socket Layer (SSL) connections for traveling. SSL is the technology web browsers and web servers use for exchanging secure information like credit card numbers.

- **Signed code.**

The agent's code is signed with DSA (Digital Signature Algorithm) public/private key algorithm. The Tryllian system architecture rejects any agents that do not have a Tryllian digital signature. Also, an agent that has been modified by any party other than Tryllian is automatically recognized as a fake and is handled accordingly.

- **Signed data.**

Each user has his personal digital signature key that is securely stored locally. This ensures that agents cannot get lost and end up in the hands of others.

1.4 AGENTWORLD® ENVIRONMENT

Where mobile agents live and work

Tryllian offers you more than the tools to build a complete mobile agent solution. We also offer you access to our global mobile agent infrastructure or AgentWorld, where your mobile agents can access all kinds of resources, agents and facilities.

If we regard the Web as a vast collection of documents, some of which offer a limited form of interaction, AgentWorld is more like a huge collection of meeting points or Marketplaces populated by mobile agents carrying out an infinite number of actions. This infrastructure includes vast information databases, online shopping catalogues, user groups and communities, and chatting and messaging services.

This is the true active computer network of the future, and it goes more than one step beyond the Web. It links the concept of ubiquitous computing to issues like consumer lifestyle and customer operations, creating an online world that will exceed current expectations of the impact of the digital revolution on daily life. Users will access their agents through a variety of different means (Web pages, mobile phones, etc.) to give their agents instructions and receive results. Your business can choose to run its own Marketplace either as part of the public AgentWorld infrastructure or as a members-only proprietary server.

2 MOBILE AGENT USES AND BENEFITS

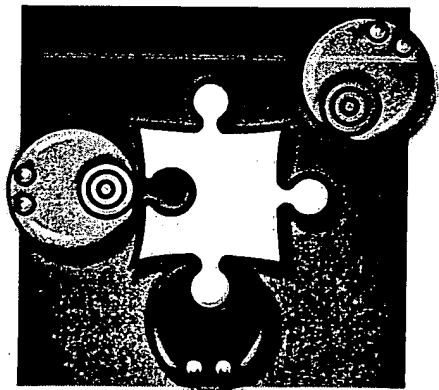
There are a vast number of possible commercial applications of mobile agent technology. In this chapter, three of the most practical current uses for this technology have been outlined, geared towards specific areas of business: Web portals/ISPs, e-commerce businesses, and hardware manufacturers. The fourth and final section of this chapter indicates one of the main possible future applications of mobile agent technology.

2.1 COMMUNICATION AGENTS

*Mobile agents
can act as your
customers'
online
representatives*

Tryllian's mobile agent technology can help your business develop a user community and even link it to others. A mobile agent application developed specifically for your business's customer base will not only bring your business invaluable information about your customers' preferences and profiles; it will also give you the opportunity to tailor your company's content to your customers' needs on a one-on-one basis.

Mobile agents can seek out other agents with similar KnowYou profiles to help users contact each other and build active communities of potential customers. Users can start sending each other their agents, who could stop by their Home Bases to inform each other of an event, a bargain, or just to chat. These agents can offer users any number of services including dating, auctions, and trading. They can exchange, find and share any kind of data. And they can do all of this while the user is offline.

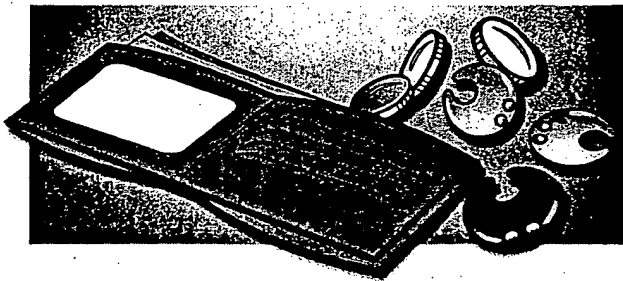


This form of community building will allow unprecedented access to user needs and preferences, as well as giving users the means to build up their own communities tailored to their own wishes.

2.2 SHOPPING AGENTS

*Mobile agents
can target your
customers on a
one-to-one
basis*

Mobile agents offer the potential to revolutionize e-commerce. Tryllian's technology gives businesses the ability to customize their offerings to each of their customers in the liquid trading exchange of the digital economy. Mobile agents handle the price negotiation process by dividing it into smaller bits that can be rearranged and restructured according to each customer profile. Agents offer the possibility of grouping transaction steps as customers change positions, physically and logically. In turn, businesses can begin to bundle products and services to the customer profile on a one-to-one basis.



This introduces the concept of *individual automated intelligent bartering* into e-commerce. As agents learn more about their users' behavior, they can begin to seek out and offer additional associated products and service to the customer. Moreover, vendor agents can begin to offer special

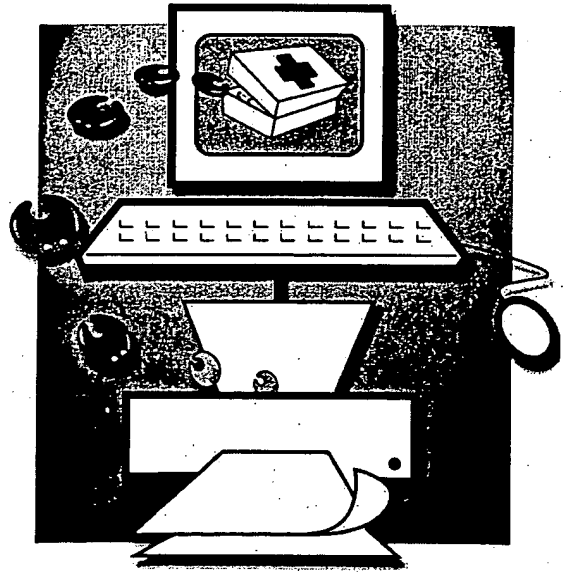
deals based on buying patterns of their customers' agents such as volume discounts, or offer supporting services and products.

The customer benefits of mobile agent technology in an e-commerce setting are fairly obvious: reduced order cycle and additional value-added products and services. The customer spends less time browsing in search of a particular product or on the lookout for something interesting. The mobile agent, making use of the user profile it carries, can take a lot of work out of its user's hands and can contact the customer at the right time with the right offer, wherever they are located. Over time, the customer sees the agent coming back with increasingly personalized results as the user profile develops and customer loyalty increases.

2.3 REMOTE MANAGEMENT AGENTS

Mobile agents can service, repair and diagnose any software-driven system or device.

Tryllian mobile agents can be used in industry not only to reduce operational costs by remote management, but also to open up new market opportunities. Agents used for diagnostics and repair can lower the costs associated with system maintenance. They can monitor systems to improve configuration, report or even solve problems, and upgrade system software. Agents acting as feedback sensors can be used to regulate environmental setting such as energy usage, temperature, lighting, and bandwidth requirements to user preferences. They can carry out repairs, reconfigurations and diagnoses independently and proactively, saving companies that rely on computer or telecommunications networks enormous service and maintenance costs.



Tryllian agents can be used for enhanced customer service. Agents can be asked by helpdesk personnel to assist them in diagnosing product problems. These agents can work online reporting information as it happens to the manufacturer's service department or communicate with the user to advise him on repair instructions or when to contact a service representative. Service representatives get a head start on determining what the problem is from information the agent has already gathered.

Tryllian mobile agents can also be used as a knowledge network to reduce product development and response time by increasing collaboration across the business. User agents can exchange information with other user agents with similar design or product development profiles.

2.4 THE MOBILE AGENT HUMAN INTERFACE

*Don't talk to
a computer:
talk to a
mobile
agent!*

As ubiquitous computing spreads computer networks further and further into the fabric of daily life, the need for mobile systems that can move from one location to another and from one device to the next carrying out assignments grows ever stronger. The future of mobile agent technology therefore lies in the development of omnipresent mobile agent assistants that can take care of any computing task. Their mobility allows them to move smoothly from device to device and take care of any kind of user wish from dialing a phone number to accessing information in a complex database application. Users communicate with their agents via voice recognition software, 3D visual interfaces, or any other user-friendly method.

Using mobile agents as a means of human interface facilitates the concept of the truly universal communications device. The mobile agent interface is one that increases the mobility of the user by transcending the barriers of geography and technology. The interface can manifest itself to the user in the forms of a carry-along device or a 3D holographic projection as the virtual representative of the agent. This interface is the central port for user interaction with content or transaction requests. Behind the scenes, the mobile agent will be working through the extensions of Tryllian's AgentWorld to support and provide a more agreeable user experience.

The mobile agent interface provides a transparent layer between user lifestyle and technology. It becomes the central point of contact controlling and negotiating the connections between technologies and transactions as the user moves through their day. The mobile agent can be proactive; regulating environmental preferences and security authorizations, or reactive; responding to user requests for content, products or services.

3 TRYLLIAN'S AGENTWORLD

Earlier chapters have illustrated some of our core technology and possible uses and benefits for our mobile agent technology. This chapter will explain on a non-technical level how Tryllian's mobile agent system works.

3.1 MOBILE AGENTS

*Virtual robots
that do what
you want*

Mobile agents are virtual robots that can carry out tasks autonomously and can travel across networks of computers and other devices. Tryllian mobile agents can be assigned tasks they know how to carry out, and have a degree of intelligence that allows them to react to and learn from their surroundings.

Tryllian mobile agents make use of artificial intelligence to achieve their tasks. Tryllian mobile agents demonstrate a level of intelligence that surpasses that of traditional computer programs by using a *sense-reason-act loop*.

The sense-reason-act loop is a mechanism that controls the interaction between an intelligent entity and a dynamic or unknown environment.

Sense: *Observe the environment and model it internally.*

Reason: *Update internal state and determine a sensible action based on the state of the environment and the internal state.*

Act: *Carry out the proposed action*

These steps are repeated until the agent has completed its task. Using this mechanism, the agent is able to anticipate unknown or changing environments and act accordingly.

Agents also learn from their interaction with users and other agents, making them increasingly effective in understanding their users' requests and successfully achieving their tasks.

For communication with their users, Tryllian mobile agents feature an intuitive, attractive user interface that instantly makes the concept of mobile agents completely understandable and appealing. The interface provides user-agent interaction no matter what device the agents are located on. It allows users to interact with their agents by clicking on them to ask them questions, dragging and dropping assignments onto them, and dispatching them out to the Internet with a given time limit to achieve tasks.

For their communication with each other, agents use an XML-based messaging system. This allows all mobile agents developed with Tryllian's Agent Development Kit to communicate with each other wherever they are on the mobile agent infrastructure. The combination of Java-based programming with an XML-based messaging system ensures complete platform independence for both the agents and their system architecture.

3.2 USER CONTACT: THE HOME BASE

Your mobile agent home

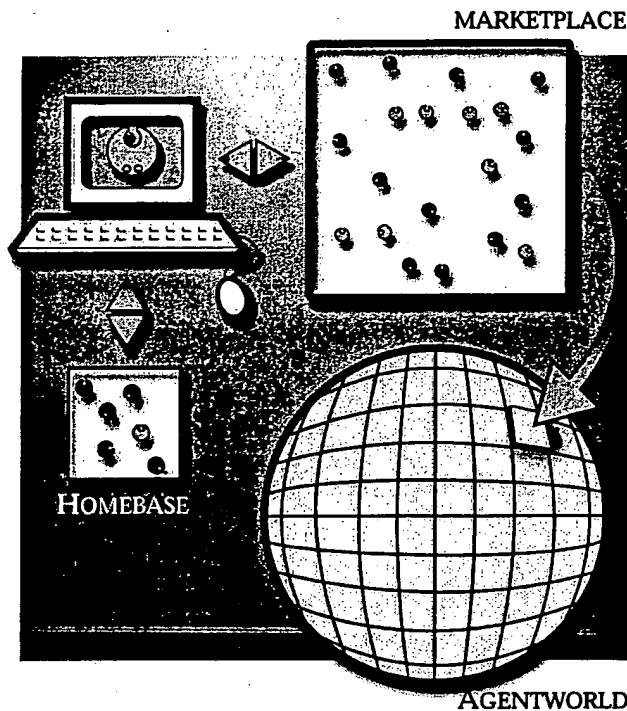
Tryllian's architecture is quite different from the traditional client-server environment: both the Home Base and the Marketplace are parts of the same infrastructure, and therefore both function as platform in the eyes of the mobile agent itself. These are protected software environments, built in Java, where agents work on their assignments by communicating with and learning from other agents.

Tryllian mobile agent users are provided with a Home Base from which they can access their mobile agents. They can then select how they will communicate with their agents from the options that developers have provided for them. Developers can use AgentFace technology to either select an existing Home Base interface or create their own, and even allow users to customize the appearance of their agents.

Users can dispatch their agents with certain tasks or working parameters from which they operate. The mobile agents then travel to and from the Marketplaces within AgentWorld to achieve these goals. Users can then check in on their agents to monitor progress or allow the agents to contact them when they have results or updates. Users and agents can contact each

other while agents are on a Marketplace via web page interfaces, SMS messaging, etc.

Home Bases are community builders in the consumer market. Users can even authorize agents from other Home Bases or Marketplaces to come to their Home Base for trading or chatting. In industry these agents can be more active in providing software updates and configuration to the Home Base.



3.3 COMMERCIAL CONTACT: THE MARKETPLACE

The mobile agent workplace

Marketplaces are where agents meet to exchange information and perform tasks. They are the virtual storefronts for businesses. It is where users' agents communicate with commercial agents for content, database access, directory services, transactions, software configuration and upgrades, and other useful resources. This buyer-seller agent relationship forms the basis for distribution of products and services within AgentWorld. Businesses can also create promotional agents to travel to other Marketplaces advising other agents interested in their products or services. Commercial agent

applications have their own Marketplaces. Agents originating from different applications can be authorized to communicate with each other.

These Marketplaces can each have different access privileges. Businesses may offer access to any mobile agent coming to their Marketplace or only allow a certain kind of mobile agent access to its information, products and/or services. Just like certain websites allow access only to members, mobile agents may 'become members' of certain Marketplaces. In this scenario, online businesses can offer customers a downloadable expansion pack that will grant their mobile agents access to its proprietary Marketplace, thereby enabling that agent to communicate with its seller agents to purchase items on their server or meet with other member agents to exchange information.

Marketplaces offer commercially oriented features for businesses. Tryllian's mobile agent environment is expandable. Newly created or enhanced existing Marketplaces are automatically available to user agents. Marketplaces are scalable to the workload demands of the agents as popularity increases.

Tryllian's mobile agent architecture ensures continuity for the user. User agents are saved before dispatch from their Home Base and every time they reach a Marketplace. This means that if ever there is a system failure (i.e. natural disaster, power failure, etc.) the agents are recalled from their initial state. This 'emergency backup' brings the agents present at the time of the server crash back to life with their original settings and all collected data when entering the Marketplace.

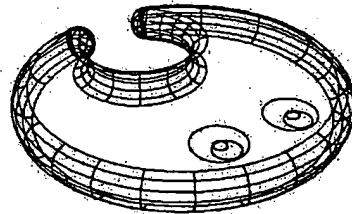
4 TRYLLIAN PRODUCTS AND SERVICES

This chapter will introduce you to the products and services Tryllian offers your business to help you create your own complete mobile agent solution.

4.1 THE AGENT DEVELOPMENT KIT (ADK)

Build your own mobile agent application

The Tryllian ADK provides businesses with a means for creating intelligent mobile agents. The ADK allows businesses to define and configure how user agents can access their product or services and obtain results from their Marketplaces. Business developers can build their own customized agents and interactions using the Tryllian ADK, or create them based on predefined agent templates.



Tryllian ADK-based mobile agents are made up of three parts: body, knowledge and behavior. The body is the part of the agent that takes care of the execution of the tasks, sending messages and moving the agent over the network. It is the most technical part of the agent and the least configurable. The agent's knowledge element contains the information the agent has about itself and its environment. It is a collection of data without any specific behavior or actions assigned to it. The behavior specifies the agent's actions. This is the part of the agent that the developer can customize to his business requirements.

4.2 THE AGENT RUNTIME ENVIRONMENT (ARE)

Creating a place to send your agents

The Agent Runtime Environment is the Marketplace software that supports mobile agents running on a network. It allows you to run a Marketplace that can incorporate information databases, messaging facilities, agent matching systems or any other kinds of agent resources you might wish to use.

Tryllian offers the following Marketplace services:

- **Marketplace subscription:** You can opt to have your mobile agent Marketplace hosted on Tryllian's network. By doing so, customers can determine Marketplace accessibility, degree of integration within the mobile agent network, without the added costs of system maintenance and administration. Customers will be charged on a per-agent basis, plus an annual service charge.
- **Marketplace license:** You can also choose to set up the ARE on your own server. This option gives you more direct access to the mobile agent server and its data. Customers will be asked to purchase a full ARE license, plus an annual service charge for having this machine maintained and its software serviced by Tryllian's Services Team.
- **Management tools:** Tryllian offers your business various management tools for your mobile agent Marketplace. These tools give you direct control over the resources, access privileges and customer data on your Marketplace.
- **Support:** Tryllian support includes software and hardware services, helpdesk user assistance, Marketplace design and implementation and configuration support.

4.3 TRYLLIAN'S DEMO APPLICATION: GOSSIP

*Gossip finds
you what you
want*

Gossip is Tryllian's demonstration application of its mobile agent software. It is a community building tool, aimed specifically at retrieval, exchange and organization of website addresses. Customized versions of Gossip can be developed for portals, communities and e-tailers adapted to the requirements for specific markets.

The idea behind the creation of Gossip is that the best source for websites interesting to Internet users are not search engines or webcrawlers, but other Internet users. By sending out Gossip agents to Marketplaces armed with several keywords and website addresses related to a particular subject, the agents make exchanges and bring back only the very best website addresses that a search engine may never find.

In order to use Gossip, users are required to download an installer program from the Tryllian website. Gossip 1.0 was introduced in February 2000 and was a big hit among computer users in the Netherlands and within the international mobile agent developer community. Gossip was downloaded by over 20,000 users in its first four months and has generated lots of positive feedback, both from users and from the Dutch national press. There is a lively Gossip community website at www.tryllian.com/gossip/.

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